PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-166205

(43)Date of publication of application : 22.06.2001

(51)Int.Cl. G02B 13/24
G02F 1/1335
G03B 21/00
G03B 33/12

(21)Application number : 11-351693

(22)Date of filing : 10.12.1999

(71)Applicant : FUJI PHOTO OPTICAL CO LTD

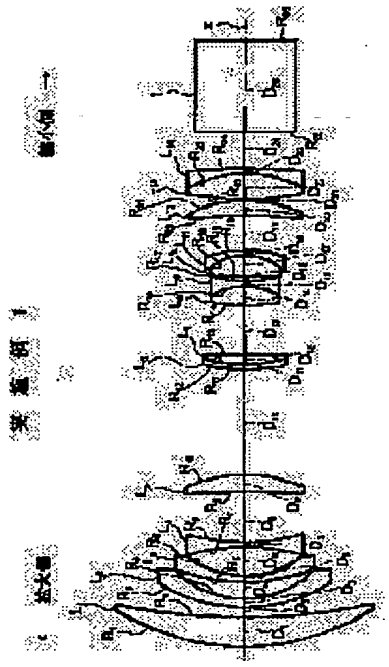
(72)Inventor : YAMAMOTO TSUTOMU

(54) PROJECTION LENS AND PROJECTOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a compact projection lens which is composed of three groups; negative, positive and positive, is insertable with a color synthesis optical system but has an adequate back focus not longer than needed and telecentric characteristics by satisfying respective prescribed conditions, has good optical performance small in distortion and chromatic aberration and has a simple inner focus structure and a projector.

SOLUTION: This projection lens is disposed, successively from a magnification side, with the first lens group G1 having negative refracting power, the second lens group G2 having positive refracting power and the third lens group G3 having positive refracting power. Focus regulation is executed by moving the lens L5 arranged on the extreme reduction side of the first lens group G1 on the optical axis X. The condition equation $0.8<DG12/f<3.0$ is satisfied when the spacing between the first lens group G1 and the second lens group G2 is defined as DG12 and the focal length over the entire system as (f).



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The 1st lens group which has negative refractive power sequentially from an expansion side, and the 2nd lens group which has forward refractive power, Come to arrange the 3rd lens group which has forward refractive power, move the lens section of said 1st lens group arranged most at the contraction side on an optical axis, and focal adjustment is performed. The projection lens characterized by satisfying the following conditional expression (1) when spacing of said 1st lens group and said 2nd lens group is set to DG12 and the focal distance of the whole system is set to f.
$0.8<DG12/f<3.0$ — (1) [Claim 2] The projection lens characterized by satisfying the following conditional expression (2) and (3) when the focal distance of said 1st lens group is set to f1 and the synthetic focal distance of said 2nd lens group and said 3rd lens group is set to f23 in a projection lens according to claim 1.
$-6.0<f1/f<-1.5$ — (2)$1.5<f23/f<4.0$ — (3) [Claim 3] The projection lens characterized by the lens section of said 1st lens group arranged most at the contraction side consisting of forward single lenses which turned the convex to the contraction side in a projection lens according to claim 2.
[Claim 4] The projection lens characterized by satisfying the following conditional expression (4) and (5) when the contraction side image point location by said 1st lens group and said 2nd lens group is set to IM12 and the focal distance of said 3rd lens group is set to f3 in a projection lens according to claim 2 or 3.
$|f/IM12|<0.125$ — (4)$1.0<f3/f<3.5$ — (5) [Claim 5] Said 3rd lens group is a projection lens according to claim 4 characterized by coming to arrange the positive lens which turned the convex to the contraction side, and a positive lens and the cemented lens of a negative lens sequentially from an expansion side.
[Claim 6] Projection projector equipment characterized by carrying a projection lens given in any 1 term among claims 1-5.

[Translation done.]

* NOTICES *
Japan Patent Office is not responsible for any
damages caused by the use of this translation.
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]

[Field of the Invention] This invention relates to the projection lens and projection projector equipment which are used for the electrochromatic display mold projector which was made to carry out expansion projection on the screen side, after compounding two or more images which have color information which is mutually different especially by synthetic prism about a projection lens.
[0002]
[Description of the Prior Art] The image currently displayed on two or more liquid crystal screens (liquid crystal light valve) is piled up optically conventionally, and the electrochromatic display mold projector projected on the screen side with the projection lens is proposed variously.
[0003] Here, an example of an electrochromatic display mold projector is explained using drawing 4 . As this electrochromatic display mold video projector is shown in drawing 4 , the light source 100, The lens arrays 3A and 3B of a pair, and the 1st and 2nd dichroic mirrors 5 and 6 which separate the three-primary-colors light source, A condensing lens 4 and the 1st, 2nd, 3rd, and 4th total reflection mirrors 12, 14, 17, and 18, It had three liquid crystal display panels (for red light) 7, 8 (for green light), and 9 (for blue glow), and the dichroic prism 10 which compounds three-primary-colors light, and the this dichroic prism's 10 injection side is equipped with the projection lens 11. The above-mentioned light sources 100 are sources of the high brightness white light, such as a halogen lamp or a metal halide lamp.
[0004] The 1st dichroic mirror 5 is a red light reflex mirror, and it is a green light reflective mirror, and the die clo IKKU film which consists of dielectric multilayers which have the spectral characteristic which reflects predetermined primary lights as a mirror on a glass substrate respectively is given, and the 2nd dichroic mirror 6 is formed.
[0005] Moreover, three liquid crystal display panels 7, 8, and 9 display an image according to the liquid crystal signal which consists of liquid crystal display (TN mold, STN mold, TFT mold) components, such as the Twisted Nematic mold, respectively, and corresponds from the liquid crystal driver which is not illustrated, and carry out intensity modulation of each primary lights by which incidence was carried out.
[0006] Furthermore, a dichroic prism 10 comes to join four rectangular prisms, and the die clo IKKU film which consists of dielectric multilayers which have the spectral characteristic as a red light reflex mirror and a blue glow reflective mirror respectively is given to the two planes of composition which intersect perpendicularly, it is formed in them, and it is possible to compound red, green, and a blue three-primary-colors light to the one flux of light of the white light.
[0007] Moreover, into the system for blue glow, the field lens 20 and the relay lens 21 are allotted, and the field lenses 15, 16, and 19 are respectively arranged on the preceding paragraph of each liquid crystal display panels 7, 8, and 9.
[0008] The projection lens 11 used for the electrochromatic display mold video projector which consists of the above-mentioned configuration projects the compounded three-primary-colors light on the screen arranged on a predetermined distance, and it is constituted so that expansion projection of the full color image can be carried out on this screen.
[0009] The following properties are required of this projection lens 11. First, in order to compound light with the cross dichroic prism 10, chromatic aberration is small, it has a long back focus and it is required to be a tele cent rucksack. Moreover, in order to acquire a big projection image in a short projection distance, it is required to wide-angle-ize the projection lens 11. Furthermore, in order to be distorted and to project the square liquid crystal display panels 7, 8, and 9 that there is nothing, it is required to form low distortion.
[0010]
[Problem(s) to be Solved by the Invention] Thus, the long back focus required in order to insert the optical system which has tele cent rucksack nature by the relation between a liquid crystal display panel or an illumination system, color composition optical system, etc. about the projection lens using a liquid crystal display panel has been called for. Moreover, high-resolution-izing of an electrochromatic display mold projector and high brightness-ization progress, and development of a highly efficient and bright projection lens is called for in recent years. However, if a projection lens is high-resolution-ized and is

made bright, the migration device of the lens group in the case of being hard coming to also escape enlargement of a lens and performing focal adjustment will also be enlarged.
[0011] Although the inner focus method which constituted only some lenses of a lens group movable and realized simple focal adjustment is learned in the field of the image formation lens of an one eye reflex camera or a video camera, when this inner focus method is applied to a projection lens as it was, whenever [angle-of-emergence] is tight and does not serve as a tele cent rucksack.
[0012] Therefore, when the lens of such an inner focus method is used for an electrochromatic display mold projector, in case a color is compounded with the cross dichroic prism 10, it is difficult for there to be a trouble that an irregular color occurs on a screen, and to use the lens of the conventional inner focus method as a projection lens of an electrochromatic display mold video projector as it is.
[0013] Moreover, although the long back focus is called for in order to insert color composition optical system etc., if a back focus becomes long too much on the other hand, the whole system will be enlarged, and there is a problem that the diameter of a lens by the side of contraction will become large.
[0014] Although this invention was made in view of the above-mentioned situation and can insert color composition optical system, while having the moderate back focus which is not long beyond the need, and tele cent rucksack nature, it has the small good optical-character ability of distortion and chromatic aberration, and aims at offering a compact projection lens and projection projector equipment equipped with still easier inner focus structure.
[0015]
[Means for Solving the Problem] The 1st lens group in which the projection lens of this invention has negative refractive power sequentially from an expansion side, It comes to arrange the 2nd lens group which has forward refractive power, and the 3rd lens group which has forward refractive power. When move the lens section of said 1st lens group arranged most at the contraction side on an optical axis, focal adjustment is performed, spacing of said 1st lens group and said 2nd lens group is set to DG12 and the focal distance of the whole system is set to f, it is characterized by satisfying the following conditional expression (1).
$0.8<DG12/f<3.0$ — (1) [0016] In the above-mentioned projection lens, when the focal distance of said 1st lens group is set to f1 and the synthetic focal distance of said 2nd lens group and said 3rd lens group is set to f23, it is desirable to satisfy the following conditional expression (2) and (3).
$-6.0<f1/f<-1.5$ — (2) $1.5<f23/f<4.0$ — (3) [0017] Moreover, it is desirable for the lens section of the 1st lens group arranged most at the contraction side to consist of forward single lenses which turned the convex to the contraction side. Furthermore, when the contraction side image point location by said 1st lens group and said 2nd lens group is set to IM12 and the focal distance of said 3rd lens group is set to f3, it is desirable to satisfy the following conditional expression (4) and (5).
$|f/IM12|<0.125$ — (4) $1.0<f3/f<3.5$ — (5) [0018] And as for said 3rd lens group, it is desirable to come to arrange the positive lens which turned the convex to the contraction side, and a positive lens and the cemented lens of a negative lens sequentially from an expansion side. In addition, the above-mentioned lens section means not only one lens but two or more lenses. Moreover, the projector equipment of this invention comes to carry the projection lens mentioned above.
[0019]
[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained using a drawing. drawing 1 shows the configuration of an example 1 (an example 3 — abbreviation — the same), and drawing 2 shows the configuration of an example 2 respectively. The projection lens concerning the example of this invention consists of 14 lens (example 2 13 sheets) configurations which arranged the 1st lens group G1 which has negative refractive power, the 2nd lens group G2 which has forward refractive power, and 3rd lens group G3 which has forward refractive power sequentially from the expansion side, as shown in drawing 1 and 2. Moreover, focal adjustment is performed by the 5th lens L5 being movable on an optical axis X, and moving this 5th lens L5 on an optical axis X. Furthermore, to the contraction side of the whole system, the filter block (color composition prism) 1 is arranged.

[0020] By considering as such a lens configuration, it has a long back focus and tele cent rucksack nature, and distortion and chromatic aberration are improved. Moreover, by moving the 5th lens L5 of the 1st lens group G1 arranged most at the contraction side on an optical axis X, and performing focal adjustment, the diameter of a lens-barrel becomes small, and equipment structure is simple and serves as a compact.

[0021] And when spacing of the 1st lens group G1 and the 2nd lens group G2 is set to DG12 and the focal distance of the whole system is set to f, it is constituted so that the following conditional expression (1) may be satisfied.

$0.8<DG12/f< 3.0$ — In the (1) above-mentioned conditional expression (1), if the value of DG12/f exceeds an upper limit, enlargement and the back focus of the whole system will become long too much, and the diameter of a lens by the side of contraction will become large.

[0022] On the other hand, if the value of DG12/f is less than a minimum, a back focus becomes short, insertion of color composition optical system will become difficult, or aberration amendment of a bright lens will become difficult. Then, although color composition optical system can be inserted by satisfying the above-mentioned conditional expression (1), while having the moderate back focus which is not long beyond the need, and tele cent rucksack nature, it shall have the small good optical-character ability of distortion and chromatic aberration.

[0023] Moreover, when the focal distance of the 1st lens group G1 is set to f1 and the synthetic focal distance of the 2nd lens group G2 and 3rd lens group G3 is set to f23, it is constituted so that the following conditional expression (2) and (3) may be satisfied.

$-6.0<f1/f<-1.5$ — (2) $1.5<f23/f< 4.0$ — (3) [0024] In the above-mentioned conditional expression (2) and (3), if it exceeds the upper limit of the value of f1/f or f23/f or is less than a minimum, the balance of the 1st lens group G1, and 2nd lens group G2 and 3rd lens group G3 collapses, a moderate back focus will be taken or it will become difficult to amend many aberration. Then, by satisfying the above-mentioned conditional expression (2) and (3), as the 1st lens group G1, and 2nd lens group G2 and 3rd lens group G3 are balanced and it has a moderate back focus, amendment of many aberration is made easy.

[0025] The focal lens L5 of the above-mentioned 1st lens group G1 arranged most at the contraction side consists of forward single lenses which turned the convex to the contraction side. Thus, by using the focal lens L5 as a single lens, miniaturization of a system can be attained, the burden to the motors at the time of making it an electric focus by lightweight-ization of a focal migration group etc. can be made small, and it leads also to a cost cut.

[0026] Moreover, if the contraction side image point location by the above-mentioned 1st lens group G1 and the above-mentioned 2nd lens group G2 is set to IM12 and the focal distance of 3rd lens group G3 is set to f3, it is constituted so that the following conditional expression (4) and (5) may be satisfied.

$|f/IM12|<0.125$ — (4) $1.0<f3/f< 3.5$ — (5) [0027] In the above-mentioned conditional expression (4) and (5), if it exceeds the upper limit of the value of $|f/IM12|$ or f3/f or is less than the minimum of the value of f3/f while taking a moderate back focus — a contraction side — a tele cent — it becomes difficult to constitute rucksack optical system, the whole system is enlarged, or it becomes impossible to insert color composition optical system etc., and an irregular color will be made on a screen because tele cent rucksack nature collapses. Then, while constituting the good optical system which has tele cent rucksack nature and preventing the irregular color on a screen to a contraction side, taking the moderate back focus which can insert color composition optical system etc. by satisfying the above-mentioned conditional expression (4) and (5), miniaturization of the whole system is attained.

[0028] The above-mentioned 2nd lens group G2 comes to arrange the cemented lens which becomes order from negative lens L6 and a positive lens L7, the cemented lens (negative lens L8 which extracted in the example 2 and turned the convex to the R14 and expansion side) which consists of a convex lens L8 and a concave lens L9, and the cemented lens which consists of a positive lens L10 and a negative lens L11 (they are a positive lens L9 and a negative lens L10 at an example 2) from an expansion side.

[0029] Above-mentioned 3rd lens group G3 comes to arrange the positive lens L12 (an example 2 positive lens L11) which turned the convex to the contraction side, and the cemented lens which consists of a positive lens L13 and a negative lens L14 (they are a positive lens L12 and a negative lens L13 at an example 2) sequentially from an expansion side.
[0030] By arranging a cemented lens in this 3rd lens group G3, the chromatic aberration of magnification peculiar to a wide lens can be amended. Hereafter, the above-mentioned examples 1-3 are explained using a concrete numeric value.
[0031] The projection lens concerning the example 1 of <example 1> this invention is explained using drawing 1 . In this example 1, the above-mentioned 1st lens group G1 comes to arrange the forward meniscus lens L1 which turned the convex to the expansion side, the negative meniscus lenses L2 and L3 which turned the convex to the expansion side, the biconcave lens L4 to which the curvature side strong against an expansion side was turned, and the forward meniscus lens L5 which turned the convex to the contraction side sequentially from an expansion side.
[0032] The cemented lens of negative meniscus lens L6 by which the above-mentioned 2nd lens group G2 turned the convex to the expansion side sequentially from the expansion side, and the biconvex lens L7 to which the curvature side strong against an expansion side was turned, It comes to arrange the cemented lens of the cemented lens of the biconvex lens L8 to which the curvature side strong against a contraction side was turned, and the biconcave lens L9 to which the curvature side strong against an expansion side was turned, the forward meniscus lens L10 which turned the convex to the contraction side, and the negative meniscus lens L11 which turned the convex to the contraction side.
[0033] Above-mentioned 3rd lens group G3 comes to arrange the cemented lens of the forward meniscus lens L12 which turned the convex to the contraction side, the biconvex lens L13 to which the curvature side strong against a contraction side was turned, and the negative meniscus lens L14 which turned the convex to the contraction side sequentially from an expansion side.
[0034] And if spacing of the 1st lens group G1 and the 2nd lens group G2 is set to DG12 and the focal distance of the whole system is set to f, as shown in Table 4 mentioned later, it is set up so that f may be set to DG12/2.06. Therefore, the conditional expression (1) mentioned above is satisfied.
[0035] Moreover, if the focal distance of the 1st lens group G1 is set to f1 and the synthetic focal distance of the 2nd lens group G2 and 3rd lens group G3 is set to f23, as shown in Table 4 mentioned later, it is set up so that f may be set to f1/-2.70, and f23/f2.91. Therefore, the conditional expression (2) mentioned above and (3) are satisfied.
[0036] Furthermore, if the contraction side image point location by the 1st lens group G1 and the 2nd lens group G2 is set to IM12 and the focal distance of 3rd lens group G3 is set to f3, as shown in Table 4 mentioned later, it is set up so that |f/IM12| may be set to 3.00x10-4 and f3/f2.12. Therefore, the conditional expression (4) mentioned above and (5) are satisfied.
[0037] Hereafter, ****** N in the radius of curvature R of each lens side of the projection lens concerning an example 1, the main thickness of each lens and the air spacing D of each lens, and d line of each lens and Abbe number nu are shown in Table 1. And under this table 1, o'clock of one [0.013 times the scale factor of this] spacing of D8 and D10 is shown. However, in these the Tables 2 and 3 [1 and] mentioned later, the figure to which each notations R, D, N, and nu were made to correspond carries out a sequential increment from an expansion side.
[0038]
[Table 1]

面	R	D	N_d	ν_d
1	3.7128	0.5601	1.7923	48.8
2	9.5327	0.2037		
3	2.4934	0.1630	1.7259	55.2
4	1.5179	0.3291		
5	2.9417	0.1222	1.7725	49.6
6	1.4286	0.5599		
7	-3.3143	0.1018	1.8467	23.9
8	3.3868	0.9740		
9	-13.2042	0.3361	1.5163	64.1
10	-2.1896	2.0555		
11	3.4063	0.0937	1.5635	43.1
12	2.3421	0.1886	1.8052	25.4
13	-198.5832	0.9672		
14	3.9366	0.3613	1.7283	28.5
15	-0.9260	0.0937	1.6889	31.1
16	1.7647	0.1023		
17	-182.0326	0.4086	1.4875	70.2
18	-0.8297	0.0937	1.8467	23.9
19	-2.1482	0.6652		
20	-6.3824	0.2990	1.7130	53.9
21	-1.8421	0.0122		
22	4.5873	0.5039	1.7489	48.3
23	-1.7965	0.1018	1.8467	23.9
24	-8.1451	0.7044		
25	∞	1.7436	1.5163	64.1
26	∞			

倍率0.013倍時の間隔

8	1.0034
10	2.0261

[0039] Next, the spherical aberration about the above-mentioned example 1, astigmatism, distortion, and the chromatic aberration of magnification are shown in drawing 3 . According to each [these] aberration Fig., it is clear the projection lens's concerning an example 1 to maintain good optical-character ability.

[0040] The projection lens concerning the example 2 of <example 2> this invention is explained using drawing 2 . The projection lens concerning this example 2 is considered as 13 lens configurations fewer one sheet than the projection lens concerning the above-mentioned example 1 as shown in drawing 2 . Mainly It considers as the biconvex lens to which the curvature side where the 5th lens L5 of the 1st lens group G1 arranged most at the contraction side is strong against a contraction side was turned. The 7th lens L7 which constitutes a cemented lens with 6th lens L6 of the 2nd lens group G2 arranged most at the expansion side is used as the plano-convex lens which turned the convex to the expansion side. It extracts between the 7th lens L7 and the 8th lens L8, 2 is prepared, and the 8th lens L8 differs from the thing of the above-mentioned example 1 at the point made into the negative meniscus lens which turned the convex to the expansion side.

[0041] In addition, if spacing of the 1st lens group G1 and the 2nd lens group G2 is set to DG12 and the focal distance of the whole system is set to f, as shown in Table 4 mentioned later, it is set up so that f may be set to DG12/1.54. Therefore, the conditional expression (1) mentioned above is satisfied.

[0042] Moreover, if the focal distance of the 1st lens group G1 is set to f1 and the synthetic focal distance of the 2nd lens group G2 and 3rd lens group G3 is set to f23, as shown in Table 4 mentioned later, it is set up so that f may be set to f1/-3.58, and f23/f2.86. Therefore, the conditional expression (2) mentioned above and (3) are satisfied.

[0043] Furthermore, if the contraction side image point location by the 1st lens group G1 and the 2nd lens group G2 is set to IM12 and the focal distance of 3rd lens group G3 is set to f3, as shown in Table 4 mentioned later, it is set up so that |f/IM12| may be set to 6.49x10−2 and f3/f1.90. Therefore, the conditional expression (4) mentioned above and (5) are satisfied.

[0044] Hereafter, ****** N in the radius of curvature R of each lens side of the projection lens concerning an example 2, the main thickness of each lens and the air spacing D of each lens, and d line of each lens and Abbe number nu are shown in Table 2. And under this table 2, o'clock of one [0.013 times the scale factor of this] spacing of D8 and D10 is shown.

[0045]

[Table 2]

面	R	D	N_d	ν_d
1	3.9684	0.6099	1.7454	53.5
2	11.5330	0.2036		
3	2.4567	0.1629	1.6437	59.3
4	1.5029	0.3155		
5	2.8438	0.1221	1.7859	44.2
6	1.4630	0.5410		
7	−3.2741	0.1018	1.8467	23.9
8	2.7837	1.1966		
9	480.4440	0.3515	1.5163	64.1
10	−2.1739	1.5415		
11	3.6902	0.0936	1.8044	39.6
12	1.8652	0.2997	1.8052	25.4
13	117.3455	0.6992		
14	∞	0.8274	(絞り)	
15	2.9072	0.2036	1.8467	23.9
16	1.8875	0.1723		
17	−12.7493	0.3738	1.5182	58.9
18	−0.9304	0.0936	1.8201	26.2
19	−2.6965	0.4662		
20	−26.4203	0.3255	1.7859	44.2
21	−1.9952	0.0122		
22	3.3440	0.4762	1.6854	51.9
23	−2.2395	0.1018	1.8467	23.9
24	−47.8082	0.6519		
25	∞	1.7426	1.5163	64.1
26	∞			

倍率0.013倍時の間隔

8	1.2207
10	1.5174

[0046] Next, the spherical aberration about the above−mentioned example 2, astigmatism; distortion, and the chromatic aberration of magnification are shown in drawing 3 . According to each [these] aberration Fig., it is clear the projection lens's concerning an example 2 to maintain good optical−character ability.

[0047] The projection lens concerning the example 3 of <example 3> this invention is explained. Although the projection lens concerning this example 3 is considered as the 14 almost same lens configurations as the projection lens concerning the above−mentioned example 1, it differs from the thing of the above−mentioned example 1 mainly in that the 7th lens L7 which constitutes a cemented lens with 6th lens L6 of the 2nd lens group G2 arranged most at the expansion side is made into the forward meniscus lens which turned the convex to the expansion side.

[0048] In addition, if spacing of the 1st lens group G1 and the 2nd lens group G2 is set to DG12 and the

focal distance of the whole system is set to f, as shown in Table 4 mentioned later, it is set up so that f may be set to DG12/1.86. Therefore, the conditional expression (1) mentioned above is satisfied.

[0049] Moreover, if the focal distance of the 1st lens group G1 is set to f1 and the synthetic focal distance of the 2nd lens group G2 and 3rd lens group G3 is set to f23, as shown in Table 4 mentioned later, it is set up so that f may be set to f1/−2.64, and f23/f2.85. Therefore, the conditional expression (2) mentioned above and (3) are satisfied.

[0050] Furthermore, if the contraction side image point location by the 1st lens group G1 and the 2nd lens group G2 is set to IM12 and the focal distance of 3rd lens group G3 is set to f3, as shown in Table 4 mentioned later, it is set up so that |f/IM12| may be set to 1.19x10−4 and f3/f2.16. Therefore, the conditional expression (4) mentioned above and (5) are satisfied.

[0051] Hereafter, ****** N in the radius of curvature R of each lens side of the projection lens concerning an example 3, the main thickness of each lens and the air spacing D of each lens, and d line of each lens and Abbe number nu are shown in Table 3. And under this table 3, o'clock of one [0.013 times the scale factor of this] spacing of D8 and D10 is shown.

[0052]

[Table 3]

面	R	D	N_d	ν_d
1	3.7761	0.6564	1.7432	49.3
2	10.8807	0.2034		
3	2.4948	0.1627	1.6204	60.3
4	1.5099	0.3157		
5	2.8442	0.1220	1.7859	44.2
6	1.3871	0.5568		
7	−3.2376	0.1017	1.8467	23.9
8	3.2253	0.9936		
9	−8.7215	0.3552	1.5163	64.1
10	−2.0911	1.8569		
11	3.4010	0.0936	1.7620	40.1
12	2.0452	0.1627	1.8052	25.4
13	38.1392	1.0055		
14	2.7193	0.3999	1.8052	25.4
15	−1.0240	0.0936	1.7552	27.5
16	1.7858	0.1968		
17	−9.3394	0.3382	1.4875	70.2
18	−0.8469	0.0936	1.8467	23.9
19	−2.0888	0.6869		
20	−9.1991	0.2848	1.7130	53.9
21	−1.9180	0.0122		
22	3.6012	0.4882	1.6485	53.0
23	−1.8834	0.1017	1.8467	23.9
24	−9.5915	0.6775		
25	∞	1.7412	1.5163	64.1
26	∞			

倍率0.013倍時の間隔

8	1.0238
10	1.8267

[0053] Next, the spherical aberration about the above-mentioned example 3, astigmatism, distortion, and the chromatic aberration of magnification are shown in drawing 3 . According to each [these] aberration Fig., it is clear the projection lens's concerning an example 3 to maintain good optical-character ability.

[0054]

[Table 4]
式の値

	実施例1	実施例2	実施例3
A	2.06	1.54	1.86
B	−2.70	−3.58	−2.64
C	2.91	2.86	2.85
D	3.00×10^{-4}	6.49×10^{-2}	1.19×10^{-4}
E	2.12	1.90	2.16

[0055] In addition, the projection lens concerning this invention is available also as an image formation lens it is not only used for an electrochromatic display mold projector, but used for image sensors, such as a color projector using a digital micro mirror device (DMD) or CCD, and the camera tube, and the camera using a silver halide film etc.

[0056]

[Effect of the Invention] As explained above, the projection lens and projection projector equipment of this invention Focal adjustment is performed by moving the lens of the 1st lens group arranged most at the contraction side on an optical axis X. Although color composition optical system can be inserted by satisfying the conditional expression of $0.8<DG12/f<3.0$ when spacing of the 1st lens group and the 2nd lens group is set to DG12 and the focal distance of the whole system is set to f While having the moderate back focus which is not long beyond the need, and tele cent rucksack nature, it shall have the small good optical-character ability of distortion and chromatic aberration.

[0057] When the focal distance of the 1st lens group is set to f1 and the synthetic focal distance of the 2nd lens group and the 3rd lens group is set to f23, by moreover, the thing for which the conditional expression of $-6.0<f1/f<-1.5$ and the conditional expression of $1.5<f23/f<4.0$ are satisfied As the 1st lens group and the 2nd-3rd lens group are balanced and it has a moderate back focus, amendment of many aberration can be made easy.

[0058] Furthermore, by constituting the focal lens of the 1st lens group arranged most at the contraction side from a forward single lens which turned the convex to the contraction side, the burden to the motors at the time of being able to attain miniaturization of a system and making it an electric focus by lightweight-ization of a focal migration group etc. can be made small, and it can tie to a cost cut.

[0059] When the contraction side image point location by the 1st lens group and the 2nd lens group is set to IM12 and the focal distance of the 3rd lens group is set to f3, by moreover, the thing for which the conditional expression of $|f/IM12|<0.125$ and the conditional expression of $1.0<f3/f<3.5$ are satisfied While being able to constitute the good optical system which has tele cent rucksack nature and being able to prevent the irregular color on a screen to a contraction side, taking the moderate back focus which can insert color composition optical system etc., miniaturization of the whole system can be attained.

[0060] Furthermore, the chromatic aberration of magnification peculiar to a wide lens can be amended by arranging and constituting the positive lens which turned the convex to the contraction side for the 3rd lens group sequentially from the expansion side, and a positive lens and the cemented lens of a negative lens.

[Translation done.]

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view showing the projection lens concerning the example 1 of this invention
[Drawing 2] The sectional view showing the projection lens concerning the example 2 of this invention
[Drawing 3] The aberration Fig. showing many one [0.013 times the scale factor of the projection lens concerning the examples 1-3 of this invention of this] o'clock of aberration
[Drawing 4] Drawing showing an example of the electrochromatic display mold projector which carried the projection lens
[Description of Notations]
G1 - G3 The 1-3rd lens group
L1-L14 Lens
D1-D25 Axial top-face spacing and thickness of a lens
R1-R24 Radius of curvature of a lens
X Optical axis
1 Filter Block
100 Light Source
3a, 3b Lens array
4 Condensing Lens
5 Six Dichroic mirror
12, 14, 17, 18 Total reflection mirror
7, 8, 9 Liquid crystal display panel
10 Dichroic Prism
11 Projection Lens
15, 16, 19, 20 Field lens
21 Relay Lens

[Translation done.]